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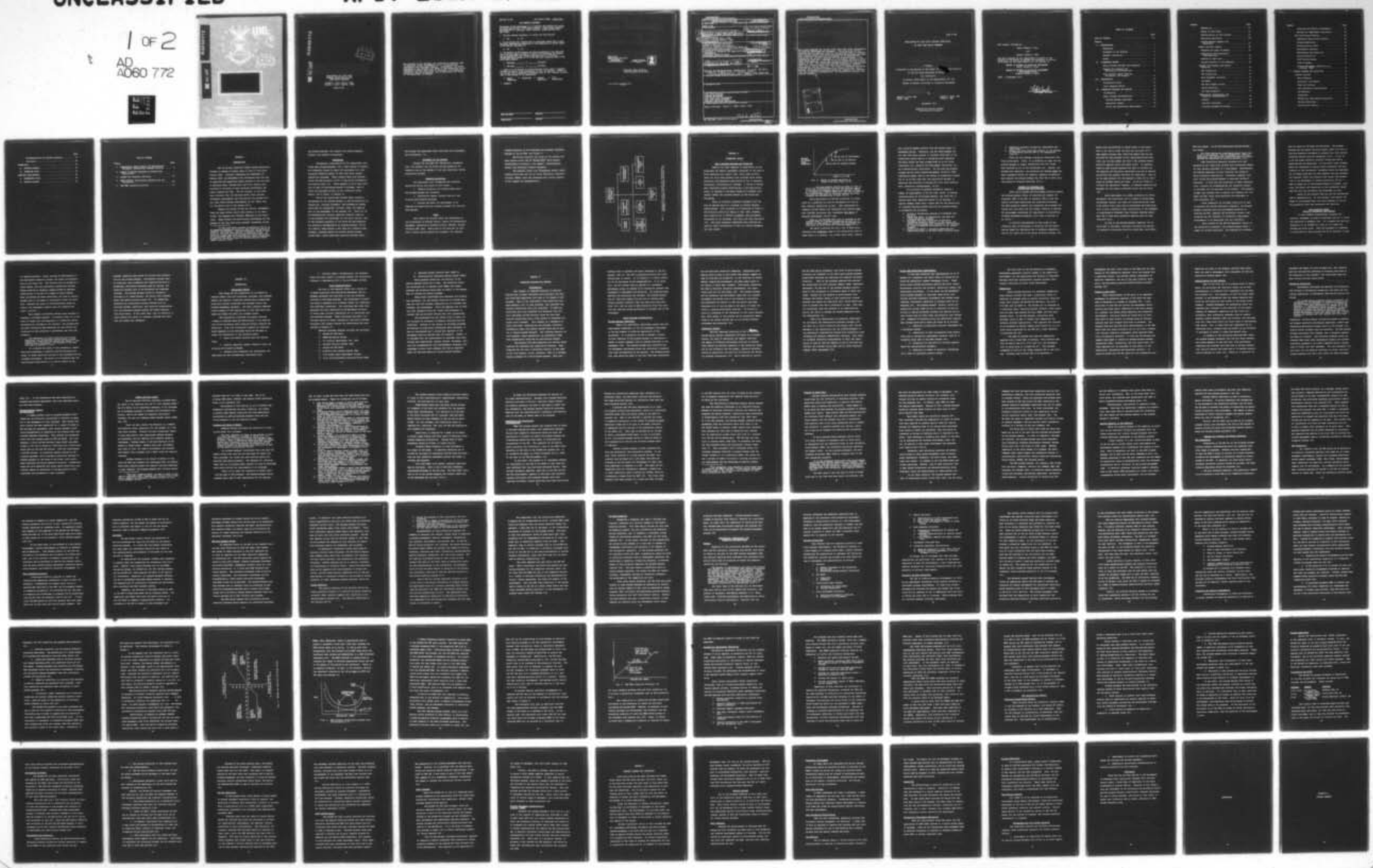

APPLICATION OF LIFE CYCLE COSTING PRINCIPLES TO LESS THAN MAJOR PROGRAMS

Joseph P. Culp, Major, USAF
Steven D. Novy, Captain, USAF

LSSR 6-78B

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This study examined ten current life cycle cost (LCC) procurements of aircraft subsystems and equipment. The objectives of the research were to identify potential LCC problem areas, to consolidate lessons learned from past and on-going LCC-oriented programs, and to provide the basis for development of an improved and simplified LCC guidance document for the program manager. The methodology used was a combination of literature review and interviews with personnel within ASD currently responsible for various aspects of LCC. The interviews focused primarily on program managers, but included others involved with contracting, testing, engineering, and LCC modeling. The study is organized into areas covering early program considerations, models and data inputs, request for proposal and source selection, negotiation, contracting, and incentive considerations, LCC verification testing, and lessons learned.

LSSR 6-78B

APPLICATION OF LIFE CYCLE COSTING PRINCIPLES TO LESS THAN MAJOR PROGRAMS

A Thesis

Presented to the Faculty of the School of [illegible] and Logistics

of the Air Force Institute of Techno[illegible]

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

Joseph P. Culp, BBA
Major, USAF

Steven D. Novy, BBA
Captain, USAF

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and

Captain Steven D. Novy

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MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(Major Joseph P. Culp)

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(PROCUREMENT MAJOR)
(Captain Steven D. Novy)

DATE: 8 September 1978

Leslie J Zambo

COMMITTEE CHAIRMAN

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CHAPTER I

INTRODUCTION

One of the most important weapon system acquisition concepts to emerge in recent years is that of life cycle costing (LCC). National leadership and Department of Defense (DOD) top management have recognized that the cost of acquiring and supporting weapon systems is far too high. In previous years, systems were (and still usually are) procured on the basis of best technical performance and lowest acquisition cost. The LCC concept, on the other hand, dictates that the Services define their minimum acceptable requirements and then procure the system which will meet those minimum requirements at the lowest cost for the entire life of the system (34:1).

Despite the intent of DOD and Service management, there are many factors which often prevent, or at least hinder, the complete and faithful adherence to LCC objectives. These factors are particularly troublesome for the manager of the less than major program[1] (hereafter called

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[1] A less than major program is defined by DOD to be an equipment acquisition which is less than $75 million in research, development, test and evaluation (RDT&E or R&D) funds or less than $300 million in production funds. In practice, a less than major program can range from a one-of-a-kind RDT&E model to a multi-million dollar production program for the entire fleet of United States Air Force (USAF) aircraft (38:2).

the program manager) who normally has severe manpower, funding, and schedule constraints.

Background

Preliminary investigation by the researchers indicated that program managers, for a wide variety of reasons, are frequently unable to apply LCC principles in a consistently effective manner to less than major system acquisition programs. These reasons range from Congressional and DOD policies (16:24) to day-to-day problems at the working level (11). There appears to be no easy solution to many of the program manager's problems, some of which are discussed briefly in the literature review herein, and in detail in Chapter IV.

One of the significant problem areas currently encountered by the program manager is the proliferation of regulations, guidance documents, and mathematical models which must be interpreted, followed, used, and complied with in the management of the program (18). While all of the documentation contains important material relating to the concepts and techniques of life cycle costing, most of the guidance presented is too broad and philosophical for effective implementation by program managers (29:ix). As a result, there exists a real need for a working level document, oriented toward the one-man system program office (SPO), which identifies potential problem areas,

and relates LCC approaches which have been both successful and unsuccessful (11).

Statement of the Problem

Current DOD and USAF LCC regulations, documentation, and guidance are too broad and philosophical for effective use by the manager of the less than major system acquisition program.

Research Objectives

The researchers will accomplish the following objectives during the course of this effort:

1. Identify potential LCC problem areas which the program manager may encounter.

2. Consolidate lessons learned from past and on-going LCC-oriented programs.

3. Provide the basis for development of an improved and simplified LCC guidance document for the program manager.

Scope

This thesis was written under the sponsorship of the Directorate of Program Control, Deputy for Aeronautical Equipment, Aeronautical Systems Division (ASD/AE), Wright-Patterson AFB, Ohio. While much of the work may be relevant to major system acquisition programs, the research

focused primarily on the subsystem and equipment programs managed by the AE SPOs (see Figure 1).

Particular attention was given to the one-man program offices within the AE "Basket-SPOs" which manage acquisitions of avionics, life support, reconnaissance, strike, and electronic warfare equipment.

The research effort also encompassed several staff offices within ASD and the Air Force Acquisition Logistics Division (AFALD) which are concerned with various aspects of LCC support and implementation.

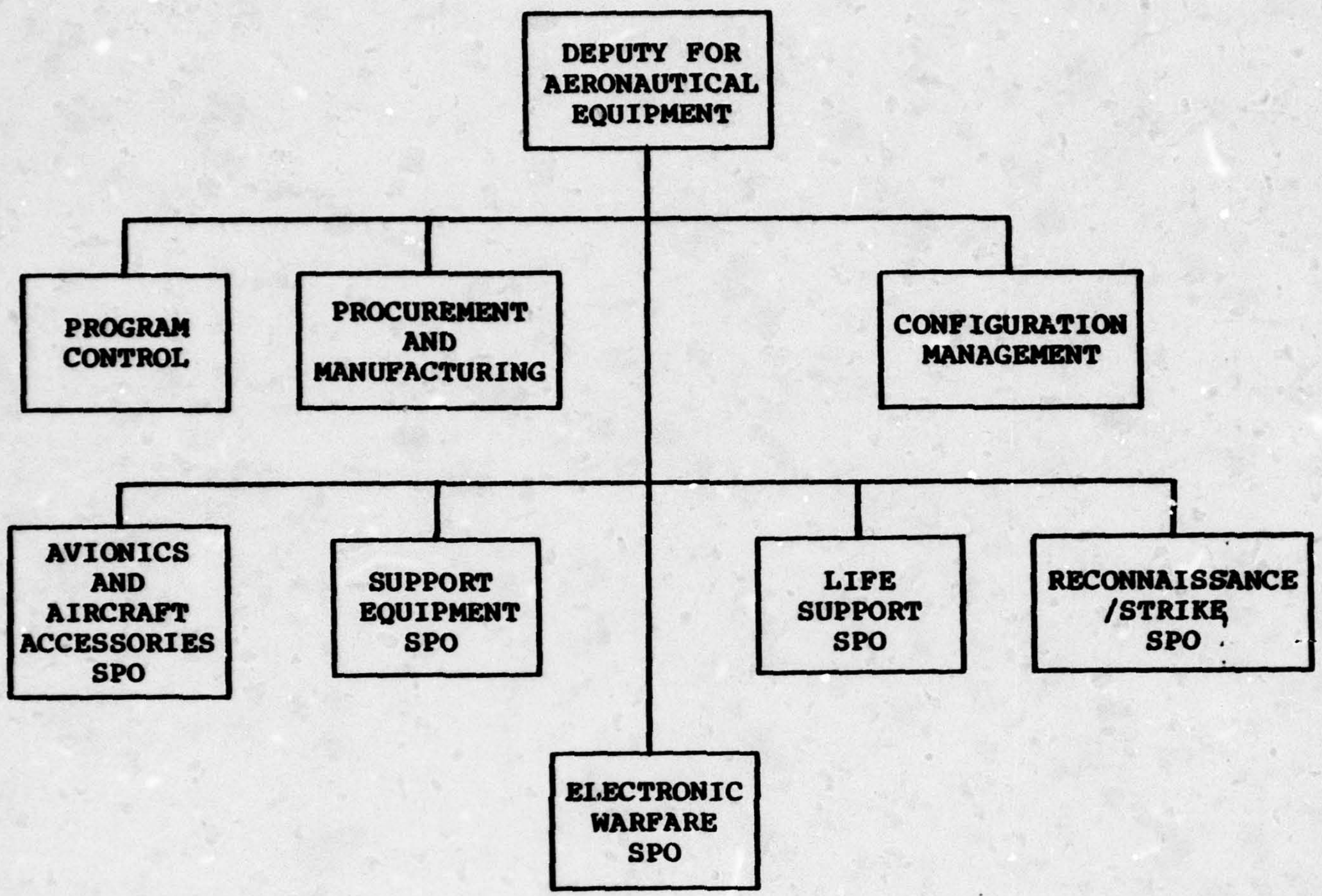

Fig. 1. Organization Chart--Deputy for Aeronautical Equipment, Aeronautical Systems Division (12)

CHAPTER II

LITERATURE REVIEW

Early Program Problems and Tradeoffs

Despite top level emphasis on application of LCC principles and general management awareness of the need to bring operation and support (O&S) costs under control, there are still many working level problems which hinder successful and economical application of LCC to research, development, and acquisition programs. A review of management literature reveals difficulties in LCC application, which, if ignored in the early stages of a program, will greatly reduce the ultimate benefit of the entire LCC philosophy.

There is virtually unanimous agreement that LCC must be applied early in a program to achieve maximum effectiveness. This situation is illustrated in Figure 2. DOD Directive 5000.28 on Design to Cost (DTC) stresses early application of DTC/LCC management and procurement principles to all programs, both major and less than major (37). The Joint Logistics Commanders have verified the need for early introduction of cost as a design parameter and have stated:

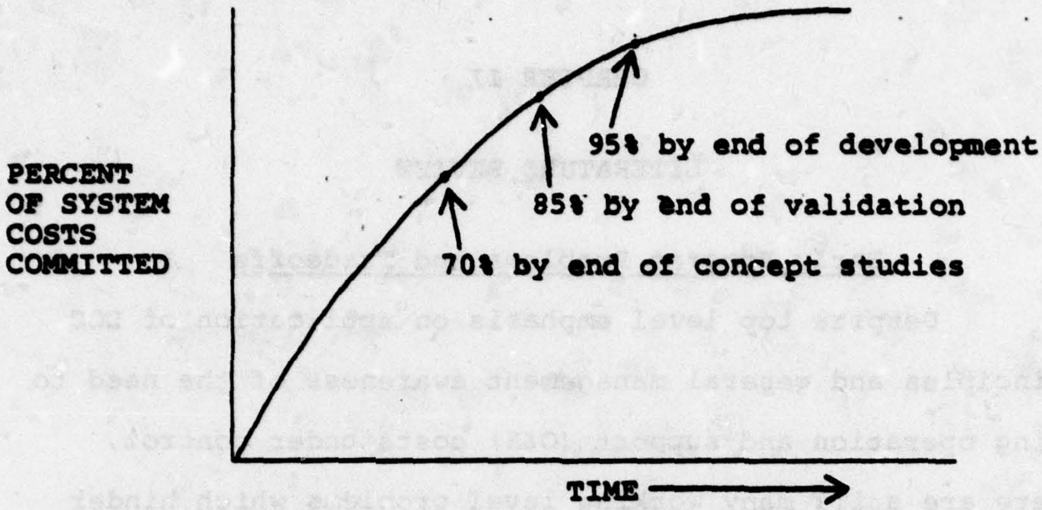

Fig. 2. Impact of Design Decisions on Future Life Cycle Costs (4:16)

> . . . the requirements generation phase is that in which cost consideration can have the greatest impact. In analyzing the possible ways of countering a threat or of supplying a needed capability, the cost of each of the possible ways must be balanced against the effectiveness and affordability of each [33:13].

Early application of DTC/LCC principles is recognized as a necessity not only by government but also by many industry authorities as well. Some representative comments include "Major cost reductions are possible <u>only</u> when [LCC/DTC principles are] considered <u>very early</u> in advanced development [16:24]" and;

> Because the designer has a lot of leverage on the ultimate cost of a product--affecting as much as 80 percent in some cases--a research and development program must be given money and attention <u>early</u> [6:7].

The above citations are only a few of many which recognize that <u>effective</u> steps to LCC optimization must be taken early in a program. As in many other areas, however,

what actually happens differs from the stated intent of management policy. Typically, the Air Force manager for the less than major program is assigned after most of the significant design work on a system has been completed. The basic design has been accomplished by an Air Force laboratory, by a research and development contractor, or by a not-for-profit institution. By the time the program reaches the Air Staff Program Management Directive (PMD) acquisition phase, much of the design is essentially frozen. Yet it is at this time that the acquisition manager is appointed and directed to proceed with full scale development, production, and deployment (16:24).

The direction to proceed frequently imposes a number of requirements in the LCC area, which, if pursued conscientiously by the program manager, may force him to neglect many other important facets of his program. A typical example taken from a recent PMD for the acquisition of a weapons delivery system required the program manager to accomplish the following:

1. Conduct a reliability program in accordance with AFR 80-5.
2. Assess and apply, as appropriate, the need for a maintainability program.
3. Implement the basic objectives of AFR 800-8, Integrated Logistics Support, to the extent compatible with program size, resources, and contracts to insure integrated consideration of all support elements.
4. Prepare and submit a logistics supportability report/evaluation to HQ USAF before contract award.

5. Consider a possible reliability improvement warranty (RIW).
6. Conduct all Life Cycle Cost aspects of the program in accordance with AFR 800-11, as appropriate [35:2-5].

There are two problems created by directions like those given above. First, it is difficult at best for the program manager to comply effectively with the volume work required by all of the directives (11). Second, and perhaps more important, the direction was imposed <u>after</u> the basic equipment design was complete, possibly eliminating many chances the program manager may have had to make early cost-effective tradeoff decisions (22:7).

Request for Proposal and Contracting Considerations

After early program and procurement planning efforts, the program manager begins to structure the request for proposals (RFP) to be sent to industry, and to plan the overall LCC-based negotiating and contracting strategy. The USAF Inspector General has recognized the problems connected with this phase and has stated, "Efforts to develop LCC procurement techniques for application to contracting, although progressing steadily, still have a long way to go [36:4]."

A critical consideration at this stage is the difficult task of developing or selecting the LCC mathematical model for contractor use in proposal preparation, and for Air Force use in the source selection process (25).

Models have proliferated in recent years to the extent that no one really knows how many are available (8:7). Some experts believe that individual models must be constructed for each program (5:29), while others state that there are too many models and that a few standard models should be applied across the board (3:66). An approach taken by some program managers has been to contract for LCC modeling and evaluation assistance with one of several contractors who possess extensive LCC experience. This is not an easy decision for the manager to make and is influenced by program timing and funds. He may be forced to contract for assistance, however, if adequate expertise and manpower are not readily available within the Air Force (20).

After development of a model structure, Air Force parameters and constraints such as number of using bases, maintenance concept, and other Air Force-controlled items which affect total costs must be determined and quantified. This is also a difficult area, particularly if the equipment is significantly different from currently deployed equipment and if firm total production amounts have not been finalized (8:5).

As soon as the program manager completes the Air Force part of the model (the model structure and inputs), all potential contractors should be consulted, even before

RFPs are issued. As one LCC-experienced program manager has stated,

> Air Force/contractor interchange should begin very early in the program. The LCC methodology, modeling techniques, and contractual commitments must be clearly defined and understood as early as possible [1:22].

Some contracting personnel disagree with this approach on the traditional grounds that contractors should not have advance knowledge of a procurement. Nevertheless, the limited experience to date validates the wisdom of early contractor consultation. Contractor feedback, however, forces the program manager to make more difficult decisions. If more than one contractor is under consideration, a variety of recommendations and suggested changes to the model will be provided to the manager. The manager's dilemma then becomes that of meshing the feedback into the model and RFP, while being equitable and reasonable to each contractor (20).

After completion of the model which will be used to evaluate the various contractor proposals, the program manager continues work with procurement personnel to finalize the RFP, complete the evaluation criteria, and structure any LCC incentive or reliability improvement arrangements to be negotiated with the contractor.

After release of the RFP and subsequent receipt of the contractor's proposals, the program manager makes a number of critical decisions. The proposed LCC estimates

must be input to the model and evaluated. The program manager and the source selection board, which will vary in size and formality according to program size, must balance technical factors with LCC estimates (1:21). If LCC is to be the prime selection criteria, incentives and/or penalties may be negotiated. At this point final arrangements for laboratory or actual field evaluation and verification of the contractors' estimates should be completed. All of these areas must be tied together into one document, the contract, which one authority has called "the weakest link in the management of system acquisition [32:21]." Here is where all of the program manager's strategy, planning, and effort are formalized in the contractual agreement for both the contractor and government to sign.

Award of the contract does not end the program manager's responsibility. On the contrary, this begins the phase of the program which will prove whether or not all the preceding effort was worthwhile and effective.

Post Contract Award: Testing, Validation, and Support

In most hardware acquisitions, avionics for instance, equipment is given a functional test as it leaves the contractor's assembly line. If it passes the test successfully, it is shipped to a user or to a depot for storage and later issue. When the equipment or component is installed on a major system such as an aircraft, it may

not operate properly. Often, because of deficiencies in the maintenance reporting system, the reason for malfunction is not clear (25). The failure could be caused by a latent defect from the contractor's production process, damage received in shipping, damage caused by improper installation, or by any of a number of other reasons. After the defect has been identified, the item is usually shipped back to the depot or contractor's plant for overhaul. Because the origin of the malfunction cannot be proven, the government normally pays for shipping and repair (2:33,34).

This example illustrates another major problem in managing a LCC-based program. If contract award is on the basis of lowest LCC, and especially if incentives and/or warranties are included in the contract, the program manager must incorporate some mechanism for the testing and validation of the contractor's performance and cost commitments.

> The importance of clearly defining and closely monitoring the verification testing cannot be overemphasized. Since the test results may require a substantial price adjustment, the validity of the test data must be assured [1:24].

It is beyond the scope of this research to recommend test procedures or specific test/verification programs, as these should be tailored to the equipment and its intended environment. The point is to recognize that the post-contract award phase is a critical aspect of the

program, requiring many months of planning and coordination by the program manager. Maintenance concepts must be finalized, test procedures and organizations must be determined, maintenance personnel must be trained, and reporting channels have to be determined and sometimes invented. The program manager should be integrally involved in all these matters, and should start arrangements long before contract award (25). By themselves, extensive and coordinated planning efforts with all involved systems, operations, and logistics organizations will not guarantee program success and lowest possible life cycle costs. On the other hand, lack of attention to these efforts may result in numerous problems and costs that are higher than necessary.

CHAPTER III

METHODOLOGY

Preliminary Effort

This study was the culmination of six months of research effort into LCC principles, programs, and problems. General and specific literature reviews were accomplished, along with limited interviews with program control and program management personnel. The early research examined various aspects of LCC application to less than major programs and formed the basis for in-depth review.

The exploratory interviews and papers revealed a number of problem areas and deficiencies in the application of LCC principles which required further research and definition. From this preliminary research an interview guide (Appendix B) was developed which was designed to assist the researchers in the following areas:

1. Detect and define working level LCC problem areas.

2. Pinpoint important lessons learned on past and on-going LCC-oriented programs.

3. Document both successful and unsuccessful LCC approaches and the circumstances surrounding each.

4. Identify models, documentation, and guidance which have been helpful to program managers and contracting officers in implementing LCC in the procurement process.

Final Research Effort

The core of the research effort was a series of in-depth interviews with exprienced management and procurement personnel who have been or are now currently involved in LCC-based programs. The researchers utilized the guide in Appendix B as a general format for conducting the individual interviews. The interviews were made with personnel who were identified by AE management as being or having been actively responsible for or associated with LCC-oriented programs. These interviews provided a significant amount of useful information from which problems, solutions, and lessons learned are consolidated and categorized in Chapter IV.

Specific programs examined included the following:

1. AN/ARC-164 UHF Radio
2. OMEGA Navigation System
3. F-4 Inertial Measurement Unit (IMU)
4. Survival Avionics System (SAS)
5. AN/ARC-186 VHF Radio
6. B-52/F-15 Tail Warning System (TWS)
7. F-16 Carbon Brake Improvement Program
8. C-141 Attitude/Heading Reference System (AHRS)

9. Advanced Concept Ejection Seat (ACES II)

10. Electronically Steerable Antenna System (ESAS)

These programs constitute the majority of LCC efforts managed within AE to date. The objective during the interviews was to discover both common and unique problems and solutions which might be useful in the management of current and future programs.

Among those interviewed were engineers and procurement personnel, but the primary focus was on program managers who have the ultimate responsibility for program cost, schedule, and performance. While the emphasis was on working level managers within AE, inputs from personnel in relevant ASD and AE staff offices were also incorporated.

The researchers did not define rigid criteria for the inclusion or exclusion of material obtained from the interviews. Because of the variety of LCC-based programs and because of significant differences among programs, it was not anticipated that a single best approach to LCC management would be derived from the research. Rather, it is intended that the consolidation of problems which have already been experienced, lessons learned, successes, failures and recommendations from knowledgeable personnel will supplement working level guidance and form an improved basis for decision making by future program managers.

CHAPTER IV

INTERVIEW FINDINGS AND RESULTS

Introduction

This chapter is composed primarily of material derived from in-depth interviews with personnel who have had first-hand experience with some or all phases of LCC programs. Most of the individuals interviewed were program managers, but, on some programs, test engineers and contract negotiators were also contacted. In addition, interviews were also conducted with personnel from the Joint ASD/AFALD LCC/DTC Advisory Group who have been involved extensively with a wide variety of subsystem and system level programs. This chapter is a synthesis of those interviews, highlighting the problems, solutions, information items, and lessons learned which may be useful to future program managers. The interview material is tied together, where appropriate, by significant items from documentation which may be particularly helpful.

The material has been separated into various broad sections for reference and organization purposes. Many items may not fit into a particular section, or may seem to fit into several, or all, sections. This is a dilemma facing a manager of a LCC-oriented program. This also

reflects what is possibly the major advantage to the LCC concept; that is, that LCC is multidisciplinary and interdisciplinary in nature. It is difficult to clearly define all of the divisions of LCC responsibility. To be effective, the LCC concept must be applied as a management philosophy across all phases of an acquisition program from conception to deployment and operation. By conscientiously applying LCC principles and concepts, the program manager and all those who support him are able to achieve much greater program visibility than has previously been possible (23), and are able to make decisions which will provide the required system performance at minimum cost to the government.

Early Program Considerations

Program Manager Commitment

Nearly all individuals interviewed agreed that program manager commitment to the LCC management philosophy is the key element in effective application of LCC principles. It is possible for LCC to become a "block-filling" exercise if the program manager is unwilling or unable to devote adequate time or program resources to LCC management (28). The program manager must establish the LCC management philosophy within the contractor's organization from the beginning of the program. The program management team should be aware of the fact that most contractors

are not motivated toward LCC reduction. Contractors frequently make as much or more money from product support as they do from R&D and production, so LCC reduction by better design, simplified maintenance, and fewer spare parts is not really in their best interest. Contractual incentives may help to motivate contractor performance, but incentives alone are not the answer (26). The program manager and his technical and procurement teams must act together throughout the entire life of the program to discipline the contractor and instill in him the belief that USAF decisions will in fact be made on the basis of lowest LCC within a required performance envelope. LCC should be formally introduced in the conceptual or full scale development (FSD) phases of the program and be continually emphasized at all design reviews and in all contacts between government and contractor (39).

Laboratory Support

The most important principle of LCC is that the system design process incorporate and focus on as primary factors the costs of operations and support functions. The impact of different maintenance policies on program costs should be seriously assessed in the conceptual phase, and by the validation and FSD phases, logistics personnel should be extensively involved with structuring and designing program alternatives (30). While required by various

DOD and USAF policy documents, this area of early program attention and tradeoffs is one which most program managers interviewed indicated was deficient and required increased attention. None of the programs examined had received any significant Air Force Systems Command (AFSC) laboratory assistance, nor had any of the program managers participated in the conceptual or validation phase of their programs. Reasons for the absence of participation vary. Probably the primary reason is that acquisition program managers are simply not identified until the Air Staff decision to proceed into FSD or production is made. When they are identified, they are assigned to an organizational entity, AE, which is managed and funded separately from the laboratories (11).

While the laboratories are primarily responsible for developing and demonstrating advanced concepts, LCC can never be a totally effective philosophy until the R&D managers in the laboratories and the program managers in the acquisition organizations develop more cooperative relationships and improved communication channels. This issue of increased laboratory participation in early LCC application is seen by some LCC experts as one of the more significant LCC problems facing AFSC and Air Force Logistics Command (AFLC) management (14).

Policy and Operational Requirements

It has been estimated that approximately 60 to 70 percent of a program's life cycle costs are driven by Air Staff and operational command management policy. These policy areas include maintenance manning and skill levels, maintenance locations and concepts, operational basing, and operational environment. If Air Staff and ASD management allow program managers to challenge these policy cost drivers and make reasonable adjustments and changes where required, significant reductions in program costs can be achieved (14). The program manager, however, should not assume that policy items are set in concrete; he must be willing to explore different concepts and question policy cost drivers when he feels there are potential cost savings (26). Examples of possible policy and operational requirement changes which would reduce LCC might be as follows:

1. Reduction in positional accuracy requirement for a navigation system.

2. Combination of USAF intermediate level maintenance with a reliability improvement warranty, such as is currently being used in the AHRS program (24).

3. Relaxation of resolution or altitude requirements for reconnaissance equipment.

4. Reduction in number of operating frequencies for a radar or electronic warfare system.

The point here is not the deletion of equipment performance parameters actually needed in the operational environment, but the questioning and deletion of desirable features which may significantly increase program costs without fulfilling an actual field requirement.

Commonality

Early program decisions for subsystem commonality among several aircraft has been a significant factor in reduction of program costs on several relatively large programs, most notably the AN/ARC-164 UHF Radio, the B-52/F-15 TWS, and the ACES II. The AN/ARC-164 was designed as a fleet-wide radio, replacing several different older radios with low mean time between failures (MTBF) and high maintenance costs. On the TWS program, contractors were directed, early in FSD, to design high commonality for multiple aircraft applications. This approach has resulted in an estimated 90 percent common parts factor for all aircraft being considered for the TWS and a large reduction in projected LCC (13).

The ACES II program also used the commonality approach with a great deal of success. This ejection seat will be used in the A-10, F-15, and F-16, and consideration is being given to include the A-7. This program attempted to build in the lowest possible LCC in the front end. Although some aircraft had to be modified to

accommodate the seat, total costs to the USAF will be lower because of the commonality approach, which was coupled with a simplified design, long periods between replacement of explosive components, and use of the same training, spare parts, and maintenance approach across multiple aircraft systems (15).

Design to Cost Goals

Early establishment of DTC goals is an important management by objectives approach to LCC which has been used to advantage on a number of programs (26). A key point here is that DOD and Service top management should realize that these goals, especially in the early phases of a program, are almost always ambitious and frequently unattainable. The goals should be viewed more as tools with which to gain control of program costs by variance analysis than firm targets which must be achieved. One program which has used DTC goals advantageously is the TWS, which tied cost goals originally set in 1974 into a production contract incentive arrangement which operated along with a reliability incentive. In this way the program management team hoped to achieve an optimum balance between acquisition costs, reliability, and life cycle costs (13). (This approach will be discussed in more detail in the Negotiation, Contracting and Incentives section.) It should be noted that the DTC goals for unit production cost

should be set early in the program, adjusted when necessary, and used as management tools throughout the R&D and acquisition program phases (26).

Identification of Cost Drivers

Even if the total LCC of a program cannot be determined, LCC principles and simulation models can be used advantageously to determine which components are the high cost drivers (14). For instance, on the F-16 Carbon Brake program, it was determined that the carbon composite heat stack was the single big cost driver in the entire brake assembly. Program management and engineering effort are therefore being focused on cost reduction of the single assembly of components comprising the heat stack (17). Conversely, many electronics programs, such as electromagnetic counter measures (ECM) and avionics, may have many high cost items which force life cycle costs to unacceptably high levels. But, if these high cost components can be identified early, program funds and effort can be allocated to refinement of design in these high payoff areas.

An example is the previously mentioned TWS, where the program manager estimates that the full scale development phase emphasis on the high cost, high maintenance components has reversed the trend from 40 percent acquisition costs/60 percent O&S costs back to 70 percent acquisition/30 percent O&S costs (13). While it is difficult to

determine the impact on total program cost, this achievement has the distinct advantage of bringing costs back to the beginning of the program's life cycle where they are more visible and more controllable.

Contractor Motivation

Maintenance philosophy and approach are substantial cost drivers in determining system LCC, and early and continuing examination of maintenance implications must be conducted.

> All system design tradeoffs should incorporate the influences of the tradeoffs on system maintainability and maintenance philosophies as well as on system performance. If system maintenance is thought of in the same way as a performance design parameter, it may be possible to design the system to better incorporate system maintenance features and approaches and also to design the system in ways that reduce the cost of maintenance and thereby the total system life cycle cost [30:16].

Frequently, allowing design contractors freedom to develop and propose innovative maintenance approaches, rather than freezing the maintenance concept early in the program, will greatly reduce ultimate costs of ownership. The TWS program allowed contractors this freedom, and it presently appears the USAF will benefit. One contractor proposed using the standard USAF three level maintenance concept, but another contractor proposed a "2-½ level" approach using a unique item of flight line test equipment. The test equipment will cost more, but the possible reduction in flight line maintenance manhours will more than offset the added equipment

costs (13). If the contractors had been constrained to standard maintenance approaches, this cost reduction would not have been possible.

Program Manager Support and Assistance

A common problem cited by program managers interviewed was the difficulty encountered in starting to apply LCC in the management of their programs. Even though life cycle costing has been emphasized for a number of years by DOD and USAF top management, most program managers found little documentation or expertise at the working level that provided adequate assistance. This problem was recognized within the last several years by ASD and AFALD. As a consequence, a joint LCC/DTC Advisory Group (ACCX) was established in 1977 and is presently functioning as a focal point within ASD for LCC and DTC matters. ACCX has consolidated a LCC/DTC library, is collecting lessons learned on LCC-oriented programs, and is providing consulting services to program managers in the areas of LCC plans, cost inputs, model selection and source selection criteria. Program managers who have consulted this group report receiving a significant amount of assistance in the application of LCC principles and procedures to their programs.

Models and Data Inputs

One of the most difficult problems a program manager faces is the selection and use of a LCC computer model.[1] Use of a model is not absolutely necessary on all programs, but as programs increase in hardware and maintenance complexity, and as the number of competing contractors increase, the use of a computer model becomes almost mandatory (28).

There are many reasons why modeling is a complex and difficult field, especially for the manager of a less than major program. Probably the most significant reason is that many people, even experienced systems managers and engineers, are not familiar with computer modeling techniques. Another reason is the proliferation of LCC models in recent years. Several years ago, LCC models were hard to find, but today's environment has produced more models than a manager with a small staff can possibly evaluate.

Another problem in the choice of models is that both the USAF and industry have developed their own models. While some industry models are superior and more desirable in many respects, the program manager must allocate scarce

[1]The term "computer model" is used to refer to the sets of equations which, together with certain other statements, comprise an executable software package (or computer program) (30:44).

program funds for the right to use them. Use of an in-house USAF model, however, may require staff assistance which is not available (12).

The purpose of this section is not to provide comprehensive instructions for model selection, but rather to present some general guidelines and some experiences encountered by previous program managers which may aid future managers in the LCC modeling process.

Purposes and Types of Models

Numerous factors influence the selection of a particular model for a program.

> The most important of these is the purpose or function that the model is intended to serve (i.e., to predict costs or merely to collect and aggregate them or both). Next in importance ranks the phase or phases during which the model will be developed and applied. This factor usually determines the availability and degree of detail of the program data that will be used in the model's calculations [30:45].

All program managers interviewed which had used LCC models stated that they had not developed new models for their programs, but rather had used existing models and modified them where necessary. The managers all indicated doubt that an all-purpose model existed or could be developed which would satisfy the requirements of all programs.

There are at least ten categories of models which could be used in LCC programs. The program manager should consider which type is most appropriate for his program,

and, in fact, he may use more than one type during the various program phases. These ten categories are as follows:

1. Cost Factor Model--a model in which each cost element is estimated by multiplying a key weapon parameter by a factor which is derived as a function of Air Force cost experience on similar weapon systems.
2. Accounting Model--a set of equations which are used to aggregate components of support costs, including costs of manpower and material, to a total or subtotal of life cycle costs.
3. Cost Estimating Relationship Model--a statistically derived set of equations each of which relates LCC or some portion thereof directly to parameters that describe the design, performance, operating, or logistics environment of a system.
4. Economic Analysis Model--a model characterized by consideration of the time value of money, specific program schedules and the question of investing money in the near future to reduce costs in the more distant future.
5. Logistic Support Cost Simulation Model--a model which uses computer simulation to determine the impact of an aircraft's flying program, basing concept, maintenance plan, and spare and support resources requirements on logistic support cost.
6. Reliability Improvement Cost Model--a set of equations that reflects the costs associated with various increments of improvement in equipment reliability.
7. Level of Repair Analysis Model--a model that, for a given piece of equipment, determines a minimum cost maintenance policy from among a set of policy options that typically include discard at failure, repair at base, and repair at depot.
8. Maintenance Manpower Planning Model--a model that evaluates the cost impact of alternative maintenance manpower requirements or the effects of alternative equipment designs on maintenance manpower requirements.
9. Inventory Management Model--a model that determines, for a given system, a set of spare part stock levels that is optimal in that it minimizes system spares costs or minimizes the Not Operationally Ready Supply (NORS) rate of the system.
10. Warranty Model--a model that assesses the relative costs of having the Government do in-house maintenance versus having this maintenance performed by contractors under warranty [8:7,8].

The program manager should examine candidate models in light of four characteristics: completeness, sensitivity, validity, and availability of input data.

Completeness means that the model should include all elements of LCC which are necessary for the decision issue under consideration. If a decision is to be made on the total projected LCC of a program, then the model should contain as many elements of cost as can be established. If, for instance, only acquisition costs are required for a decision, then only the R&D and acquisition cost elements are necessary.

Sensitivity is required for a model to be useful in design trade studies and other types of decisions which compare competing alternatives. Changes made to input parameters should be evident in output results.

Validity refers primarily to user confidence in the output of the model. If important decisions are to be made on the basis of information derived from the model, then the user should be reasonably certain the output is reliable and accurate.

For a LCC model to be useful, accurate input data must be available. This is one of the most frequently encountered problems in the LCC area. The best model available is of no use unless adequate and accurate input data can be developed and utilized (8:5,6).

No model yet developed possesses 100 percent of all these characteristics. Because vital program decisions affecting millions of dollars, important weapon systems, and numerous personnel are made on the basis of model output information, the program manager should be thoroughly familiar with the characteristics, strengths, and deficiencies of the model or models used on his program.

Negotiation and Contracting Considerations

When the program manager has selected what he feels is the most appropriate model, most experienced managers believe that competing contractors should be given the opportunity to evaluate the model and propose changes and alternatives before the final model is structured and incorporated in the RFP. This approach can be used by merely providing the contractors a copy of the model documentation as was done on the AN/ARC-164 program (25), or by including the model in a draft statement of work (SOW) as was done on the TWS procurement (39).

In any event, the purpose is to thoroughly educate all contractors in the use of the model so that they will feel confident that they are being evaluated fairly. This pre-RFP discussion approach, used also in the SAS and AN/ARC-186 procurements, appears to have been very effective because contractors have proposed changes which have improved the models, source selections have been facilitated

because all contractors submitted their proposals on a consistent basis, and post-award conflicts and protests have been minimized because all contractors knew they had been evaluated equally (28).

A problem that has been encountered on at least one program involves the proprietary nature of a contractor-developed model which was being leased by the USAF for internal use. When it was decided to provide this model to competing contractors in the course of another program, additional funds had to be paid to the model contractor to compensate him for the use of the proprietary aspects of his model (23). This type of problem can be avoided by using a government-owned model, if one is available. If not, the program manager should at least be aware of this possibility so that he can allocate program funds if required.

Another related problem is model compatibility with the contractors' data processing systems. In one case, which resulted in a claim against the USAF, contractors were provided with a LCC model card deck and directed to use the model for development of their cost data submission in response to a RFP. The model was not compatible with one contractor's computer, causing him to incur additional costs to modify his system, which he subsequently claimed from the USAF (39). The claim could probably have been avoided if a clause had been included

in the RFP stating that any costs incurred by the contractor in proposal preparation and computer modeling would be borne by the contractor.

The Electronically Steerable Antenna System program has used LCC modeling techniques in an innovative manner. Because of intricate electronic features and numerous performance and design unknowns, difficulties were encountered in establishing a DTC unit production cost (UPC) goal. To solve this problem, the program manager obtained design parameters from the contractor which were input to the RCA PRICE[2] model to develop a USAF "should cost" estimate. This estimate was then used to establish high, medium, and low negotiating targets which were tied to a contractual DTC UPC not-to-exceed goal. The UPC goal was then input to another model, TASC LCC2, to determine the total LCC and to perform basing and maintenance concept tradeoffs (7). This successful use of different models for different purposes indicates a program manager need not become "locked in" to a particular model, but rather can use a variety of models throughout a program according to his requirements and the advantages of specific models.

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[2] This parametric cost estimating relationship model is leased by the USAF from RCA. It has certain advantages which have made it the unofficial ASD standard for estimating acquisition costs (28).

Sources of Input Data

Another problem encountered by most program managers interviewed was the difficulty in obtaining accurate, adequate data which were sufficient to input to the various models used to develop LCC projections. There appear to be no quick and easy methods for program managers to acquire needed cost inputs. Many general USAF and DOD publications are available which address cost estimating models, but these usually tell the manager only how to extrapolate from existing information using techniques such as regression analysis, or provide standard cost factors, which may or may not be adequate for modeling and contractual purposes.

In early program phases managers usually start with rough estimates of equipment costs at high levels of aggregation and use simplified forms of cost estimating relationships (CERs) for estimating associated operation and support costs. As the program progresses, the work breakdown structure (WBS) forms an integral part of the cost estimating procedure.

> It is the framework within which the relationships among individual system components are defined. Once determined, the WBS provides a standard organization of program costs which serves as a basis for consistent LCC reporting, cost estimating, and computer modeling [30:17].

The CERs usually take the form of rules of thumb which may at one time have been useful and accurate, and

may still be applicable for some types of equipment. For advanced state-of-the-art avionics, for instance, historical data may be almost useless for estimating costs for new programs (26). In general, most CERs are weak and require improvement. Because of this, program managers should be cautious about placing too much faith in estimates derived from them.

Most model inputs are derived by analogy (26). This technique involves the examination of levels of effort that were required to perform similar tasks for similar systems and comparing them to the system being developed. Once levels of effort are projected, they can easily be converted to dollars or whatever basis is required by the model. This technique is probably most useful in the costing of engineering and software development tasks, but can be applied to many other development and ownership cost items as well (30:19).

Parametric cost estimating equations and models, which relate to other system parameters such as weight, power consumption, frequency, and parts count, are sometimes very useful. An example is the RCA PRICE model previously mentioned. However, lack of good historical data in many hybrid electronics and advanced materials areas sometimes limits the effectiveness of these methods (31).

In the final analysis, the program manager must seek out experienced people within AFSC, AFLC, and the using

commands who have had applicable experience and who have engineering, modeling, and cost estimating expertise that is program related. There are engineers and program managers located at ASD and within the AFSC laboratories who possess extensive management experience that can be tapped in the acquisition cost area. An often overlooked, but frequently excellent source of cost experience, can be the Air Logistics Center (ALC) item manager (IM). The IM often has years of experience working with entire classes of related equipment, and can provide useful information relating to a variety of O&S cost elements (26).

Not being able to obtain data from the using commands can be one of the more serious problems encountered by the program manager. In order to complete a thorough LCC analysis, the program manager must have reasonably firm information regarding maintenance concepts, basing, flying hours and a multitude of other items. However, especially in the early phases of a program, the using commands often cannot supply the information because of uncertainties, and political factors impacting Continental United States (CONUS) and overseas basing.

The TWS program manager, for instance, had to deal with two major commands, Tactical Air Command (TAC) and Strategic Air Command (SAC), to establish basing scenarios, flying hour programs, maintenance approaches, and maintenance manhours. A major difficulty in working with TAC

was the absence of a command focal point from which to obtain cost information. SAC, on the other hand, had a focal point, but problems were encountered with some of SAC's classified basing contingency plans (13).

Unfortunately, this pattern is repeated on many programs. Even when the operational commands are cooperative, they often have no reliable basis for estimating O&S cost inputs and the problem remains on the program manager's shoulders.

Spinoff Benefits to LCC Modeling

While the primary purpose of LCC modeling is selection of the contractor offering the equipment with the lowest projected LCC, several program managers have discovered additional advantages to the modeling process.

A major benefit of a well structured model is that it can be used to project spare parts requirements and maintenance budgets with a reasonably high degree of accuracy. This is beneficial not only to the AFSC program manager, but to AFLC and the using commands as well (31). Another advantage is that DTC goal tradeoffs and the impact of acquisition costs on downstream O&S costs for different alternatives can be evaluated by the program management team. In addition, different logistics support concepts, such as RIW versus USAF maintenance or flight line versus intermediate versus depot maintenance, can be balanced

against each other to determine the most cost effective approach for the program manager to use (23).

Another benefit mentioned is that of production option evaluation. If option quantities are contemplated or are included in the production contract, the LCC model can be used to evaluate the effect of exercising the option versus initiating a new procurement. The impact of option exercises on future logistics support and spares requirements can also be determined (19).

Finally, the LCC model can be used as an integral program control tool throughout the life of the program to measure various LCC goals and milestones against achievements and revised program estimates (23).

Request for Proposal and Source Selection

RFP Preparation

Preparation of the RFP for an LCC-oriented program involves several considerations which are different from other types of programs. Probably the most significant is that the USAF's intent to use LCC as a source selection criterion for development or production should be clearly stated in the RFP. In addition, all other major source selection evaluation criteria should be included, and their relative importance should be indicated (31).

The most desirable approach, time permitting, appears to be to provide a draft RFP to all competing contractors.

The draft RFP should contain, as a minimum, source selection criteria, complete description and instructions for the LCC model to be used, contemplated incentive or RIW provisions, and provisions regarding qualification and/or verification testing to be required (23). After prospective contractors have had a reasonable period of time to examine and evaluate the draft RFP, a bidder's conference should be scheduled so that all contractors are given the opportunity to present any questions they may have about the RFP and the LCC approach to be used. This insures that all contractors will have the same information and will be able to submit their proposals on an equal basis. This approach sometimes has the added advantage of clarifying and improving the quality of the final RFP by allowing the program management team to incorporate worthwhile contractor suggested changes (25).

<u>RFP Flexibility</u>

As a general rule, the RFP should be as definitive as possible, containing specific line items for all known equipment requirements, options for increased quantities, ground support equipment (GSE), data items, reprocurement data, warranties (if required), and any contractor field support that is anticipated. In a competitive LCC procurement, thorough planning of the RFP is the key to program success at lowest LCC. After the production contract award,

the program is normally no longer competitive, and the winning contractor has little, if any, incentive to provide further reductions to ownership costs. An apparently excellent example of this approach is the AN/ARC-186 VHF Radio, which included all of the above mentioned items plus others, in what turned out to be virtually a total package acquisition (19).

On the other hand, if the program is a sole source procurement, leaving requirements as flexible as possible may be beneficial. This depends greatly on the size and attitude of the contractor and his desire for future business, but if the contract is properly incentivized, the contractor may be motivated to develop and propose innovative and more reliable design approaches, economical maintenance concepts, and effective incentive arrangements (7).

Work Breakdown Structure

Contractors should be required to submit the rationale and supporting information to back up their LCC estimates. Standardized bid formats which utilize a detailed WBS (provided in the RFP) can be extremely helpful in comparing contractors' LCC estimates and can also help in assessing the differences in proposed LCC by pinpointing cost drivers that are unusually high or low (25). If possible the WBS should be tied into specific RFP line items which are in turn tied into the LCC model elements. The

three-way correlation of WBS to RFP to model may not be totally possible, but the higher the degree of correlation that is achieved, the easier it will be for the source selection team to evaluate competing proposals (39).

LCC Model

The RFP should clearly define the objectives of and the procedures for using the LCC model in the source selection process. If a draft RFP and bidders conferences have been used, all contractors should be well aware of the characteristics and mechanics of the model by the time the RFP is received.

On some earlier LCC programs, bidders were requested to specify their own methodology for estimating life cycle costs. However, most recent programs such as the OMEGA Navigation System, the AN/ARC-164, the Tail Warning System, and the AN/ARC-186, have supplied the model to be used by all contractors. Generally, all program managers advocate the use of government-furnished models because it improves the comparability of contractors' estimates and facilitates both contractor and USAF tradeoff studies.

Normally, two versions of the model should be used in the RFP--a simplified model and an algebraic model. The simplified cost model sets forth the basic structure of the LCC model in summary, nonquantitative fashion. Its inclusion in the RFP is useful to both government and

contractor personnel at higher levels who do not require knowledge of model details but who may need to be acquainted with general structural features and model characteristics. The algebraic model, of course, must be all-inclusive and contain all model equations and complete definition of all pertinent variables (30:27,28).

RFP Data Element Values

An important factor in the RFP is the complete listing and clear definition of each LCC model data element. The values of these variables in the cost equations are at least as important as the model equations themselves in calculating LCC. The RFP provisions should specify the source of each data element, whether government-furnished, contractor-furnished, independent estimate (such as a consulting contractor), or a value from USAF standard cost factor manuals. The contractor-furnished items should be clearly identified. For contractor convenience and bid standardization, blank tables containing government-furnished values can be provided. The program manager must take extreme care to estimate costs as accurately as possible for government-provided data to ensure valid model output and to be able to defend against possible later contractor protests as to data validity and accuracy.

The RFP should request that contractors provide technical rationale which supports all contractor-furnished

inputs. If possible, the inputs should be backed up by actual preproduction test data for values such as projected component failure rates. The program manager can expect overly optimistic model value inputs from bidders. Therefore, deterrence against bidder gaming and optimistic bias must be built into the source selection process. The RFP must specify values that are detailed enough so that they can be screened and compared by cost analysts and logistics personnel against an independent cost estimate.

If substantial uncertainty exists about some of the more critical input variables, the RFP should require that bidders submit more than one estimate, for instance, the most likely estimate, plus pessimistic and optimistic estimates. Another approach may be to require a probability distribution of possible values. Since this additional data can be expensive and time-consuming to collect and verify, the RFP should require submission only if the program manager is reasonably certain it can be used in source selection or other important program decisions (30:29,30).

<u>Source Selection</u>

The primary objective of LCC analysis during the source selection process is to provide the source selection authority (SSA) logistics support cost visibility in his decision-making process (23). The specific objectives of LCC analysis are to:

1. Verify the accuracy of the contractors' LCC calculations;
2. Verify that a common interpretation of the LCC provisions of the offerors in constructing their LCC proposals has been achieved;
3. Disclose the relative differences in the calculated LCC and support costs of the contractors [30:41].

Accomplishment of these objectives requires the assembly of personnel who possess a broad range of expertise in program management, material management, engineering, cost analysis, procurement, and contract law. On the AN/ARC-164 source selection, for instance, the Source Selection Evaluation Board (SSEB) was divided into teams for pricing, technical, contracts and legal, reliability, maintainability, quality assurance, production, and life cycle costing. The LCC team was considered unique in that it had to work closely with most of the other teams to effectively evaluate the reasonableness of the contractors' LCC proposals. Since LCC was the major factor in selection of the production contractor, the role of the LCC team was critical in the source selection process (1:7).

Use of LCC as a source selection criterion is of little value in motivating contractors to propose designs and approaches which will minimize ownership costs unless they are convinced the USAF can distinguish between high and low LCC alternatives (9:13.4). Two approaches which have been apparently beneficial in motivating contractors are independent cost and reliability estimates and LCC team visits to contractor's plants.

The independent cost and reliability prediction estimates may be accomplished by either in-house USAF teams (which are separate from the source selection teams--for instance, a team from one of the ALCs), or by a consulting contractor on contract to the program office. The point is that the contractors should be made aware that their proposals will be independently evaluated by at least one group that is completely separate from the SSEB. This approach, used on several programs such as the AN/ARC-164 and the F-4 IMU, is effective in providing increased visibility to the SSA and in motivating contractors to provide accurate information, since they know they will be evaluated by multiple organizations (31).

The other approach was used during the TWS FSD phase. While contractors were finalizing designs and preparing proposals for the production contract award, the LCC team from the SSEB was sent to the competing contractors' plants to evaluate reliability and maintainability factors, design approaches, and other LCC aspects of the procurement. This provided high visibility to the government's intent to use LCC as a major award factor and very likely provided further motivation to the contractors to propose their lowest LCC designs (13).

LCC Team Formation

Assembling a competent LCC team to evaluate contractors' proposals is a critical element in the source selection process. This team should include not only cost and modeling experts, but also reliability and maintainability engineers, and, if hardware is available, actual "hands-on" maintenance personnel from AFLC and the using commands (25). In any event, the goal of the program manager should be the assembly of a team that is capable of independent verification and analysis of all aspects of the contractors' proposals. If the desired personnel are not available within the USAF, consideration should be given to obtaining assistance from an independent contractor who specializes in modeling, reliability analysis, or whatever aspect of LCC evaluation expertise the program manager requires (39). This may create a significant drain on scarce program resources, but unless the USAF can conduct accurate, independent analyses of contractor proposals, the advantages of LCC competition are lost.

Even after source selection, the LCC team has proven helpful to some program managers by performing as consultants on various aspects of LCC, such as engineering change proposal (ECP) evaluation and maintenance problem analysis, during production and field verification testing. Keeping the team together has been a significant problem, as most members are normally given new assignments after source

selection has been completed. Program managers should attempt to maintain team identity, possibly on a part-time basis, at least until the completion of verification testing, because many LCC-related questions and problems continue to be encountered throughout the program management process (13).

Negotiation, Contracting, and Incentive Considerations

General

Signature of the contractual document by the government and the contractor culminates long months, even years, of effort on the part of the USAF program management team. The contract specifies both government and contractor obligations which must be fulfilled to ensure the program's objectives are achieved.

> The success in implementing life cycle cost procurement depends to a great extent upon rigorous discipline in carrying out the government's obligations. These obligations are significantly greater than a contract for the same equipment that does not contain life cycle cost procurement provisions. The importance of establishing and maintaining credibility cannot be overemphasized. In fact, the enforceability of life cycle cost contractual provisions are contingent upon the government carrying out its obligations [9:15.1].

The final form of the contract will be contingent upon many factors such as the competitive situation, complexity of equipment, maintenance approach (i.e., depot versus RIW), incentive provisions, and qualification and/or verification testing requirements. Ensuring that the

contract thoroughly and completely specifies what is expected of the contractor while protecting government interests is particularly critical in a LCC procurement. Normally, once the production contract is signed, the program is no longer competitive and the contractor has no further incentive to reduce the USAF's ownership costs beyond what is required by the contract.

Contract Provisions

Each contract must be organized according to specific program requirements. The AN/ARC-164 contract is a good example of a program which used a logical contract methodology and organization to implement LCC objectives. The AN/ARC-164 contract was divided into eight parts for ease of management and administration as follows:

1. Overview
    a. General statement of LCC objectives
    b. Definitions
    c. Engineering change proposal provisions
2. LCC Model
    a. Simplified
    b. Algebraic
3. Verification Test Program
    a. Procedures for measurement
    b. Failure definitions
4. Price Adjustment Provisions
    a. Positive and negative incentives
    b. Procedures for adjustment

5. Option Provision

   a. Identification of each replaceable unit
   b. Unit prices and failure rates
   c. Option for procurement of units at fixed prices

6. Work Breakdown Structure

   a. Standardized methodology for making LCC estimates
   b. Component identification at various levels of detail
   c. Item/component removal and repair information

7. Government Furnished Data

8. Corporate Commitment Certification

   a. Required signature of high level official
   b. Ensured corporate awareness of LCC procurement (1:9,10).

Of course, not all programs will have the same organization and provisions, but, because of the unusual complexity of many LCC procurements, a well organized and complete contract will facilitate administration and interpretation of contract requirements.

Intrinsic Program Incentives

The use of incentive/penalty arrangements or reliability improvement warranties varies greatly according to individual program requirements. At least four current programs have followed the general philosophy that incentives are not required if LCC is emphasized early and built in during the front end of a program. These programs have all followed somewhat different approaches.

The program office managing the F-16 Carbon Brake improvement has awarded relatively small development contracts to all major military wheel and brake suppliers. Each contractor is designing and providing an improved version of the carbon composite heat stack for the brake assembly. Tests are being conducted on both the F-16 flight test aircraft and on the Air Force Flight Dynamics Laboratory dynamometer to derive a projected number of landings for each competing brake. At the conclusion of the test program a production competition will be conducted. At this point the only contractor input to the USAF LCC model will be a unit production cost for each brake assembly. From the UPC provided by the contractors and the USAF-derived number of landings per brake assembly, the USAF will be able to award a long-term production contract based on lowest LCC. The incentive for the competitors is to design the most economical brake possible because of the tremendcus future business potential in the F-16 program (17).

The Advanced Concept Ejection Seat development relied on competition during the FSD phase to provide the incentive for design refinements and innovations which minimized ownership costs on this equipment which is common to the A-10, F-15, and F-16. The program management team believed that the combination of early competition and production business potential provided sufficient motivation

to the contractors and that formal incentives in the production contract would not significantly reduce costs (15).

The F-4 Inertial Measurement Unit program manager also used competition during the FSD phase to ensure lowest LCC. A slightly different concept used on this program, however, was the addition of an unusually rigorous Production Reliability Test (PRT) which each production unit must pass before government acceptance. The PRT is a fifteen-cycle test which includes acceleration, temperature, humidity and vibration. The assumption is that if the equipment can pass the PRT, it can withstand almost any condition encountered in the field during its design life. Since each unit must pass the test, the contractor cannot "gold plate" the test units.

Infant mortality is also a factor, in that units with latent manufacturing defects are normally discovered early as a result of the PRT. The incentive in this contract is that the contractor must do good design work and produce an extremely rugged unit to pass the PRT; otherwise he is not reimbursed. The USAF has no contractual responsibility to accept a unit until the PRT is passed as witnessed by a USAF or Defense Contract Administration Services (DCAS) inspector (31).

Finally, the Survival Avionics System is a program which will apparently achieve a low LCC without the use of incentives. While the prime contract for this program

was not competitive, the subcontract for the survival radio portion, the high cost driver, will be. Low LCC will be achieved by placing continual emphasis on design refinements in the early program and by retaining competition on the high cost subsystem (23).

While it is not possible to build in minimum LCC at the front end of many programs, program managers should emphasize early design tradeoffs and other LCC-reducing actions whenever possible. This is a key concept which requires the following elements:

1. Program manager dedication
2. Time to make refinements and tradeoffs
3. Funds to invest in early design work
4. Low LCC design objectives
5. Top management support
6. Constant communication with the contractor(s) emphasizing LCC reduction objectives (23).

If minimum LCC is designed into hardware early, acquisition costs are usually increased, but O&S costs and LCC can be decreased as a result. Additionally, complicated incentive arrangements and field verification testing may not be required, further reducing costs to the government.

Incentive and Penalty Arrangements

Contractual arrangements in which the contractor is either rewarded or penalized monetarily for meeting or

missing cost and/or performance goals are widely debated within DOD and industry. Incentive effectiveness appears to vary widely according to type of program, competitive climate, business potential, and many other variables. Some programs have intrinsic characteristics which makes the use of special incentives unnecessary. Other programs, however, seem to require reward and penalty features to motivate contractors to achieve cost and performance targets. Instead of attempting to present firm decision rules for the use or non-use of incentives in LCC contracting, there are some general considerations which experienced program management, contracting, and cost analysis personnel have shared with the researchers.

1. Incentive and penalty arrangements are the best approach to LCC contracting, especially if a large percentage of program costs are O&S (28).

2. If O&S costs are 5 to 10 percent of total program costs, incentive arrangements directed at reducing O&S costs are probably not required. Instead, program management effort should be directed toward driving down acquisition costs (28).

3. If projected equipment MTBF is greater than approximately 400 hours, especially for subsystems and equipment on fighter type aircraft, then O&S costs will not be a very significant percentage of the program costs.

Therefore, DTC UPC incentives are probably more effective (31).

4. Positive incentives are not usually effective contractor motivators. The possibility of a large penalty will provide more motivation than any other factor (39).

5. Incentives sometimes help to motivate contractors toward minimizing LCC, but incentives alone are not the answer. Program managers must establish an LCC management philosphy within the contractor's management structure, and the entire program management team must continually provide LCC discipline (26).

6. Negative incentives are generally more powerful in smaller subsystem and equipment-level programs. Positive incentives are generally more influential in major system programs (26).

7. Contractors "game" themselves out of positive incentives and protect themselves against negative incentives. They bid based on the probability of obtaining future business at least risk (26).

The AN/ARC-164 program is one which pioneered the use of positive and negative incentives on LCC procurements. Contractors were allowed to propose both an acquisition cost and a guaranteed O&S cost-to-the-USAF total. If the contractor is successful in increasing equipment MTBF such that ultimate O&S costs are reduced, then the contractor will receive a share of the saved costs. Conversely, if

O&S costs are greater than guaranteed, the contractor will be penalized. This sharing arrangement is shown in Figure 3.

It now appears that the contractor bid at a point (90 percent acquisition costs/10 percent O&S costs) where it will be almost impossible to achieve the positive incentive area. However, the design effort was adequate to achieve a very high MTBF, which is now approximately 2200 hours, and which insures the contractor will not be penalized. Although the contractor apparently did not receive motivation from the positive incentive, the USAF did procure what is evidently a superior system at a low LCC. On this basis, the positive/negative incentive approach on this program must be judged a success (10).

The Electronically Steerable Antenna System program is pursuing a different incentive approach which appears promising. To insure adequate contractor attention to LCC, a reliability incentive was negotiated into the FSD contract. To guard against overemphasis on a high MTBF design and resulting acquisition costs which are excessive, the reliability incentive was coupled with a DTC UPC goal.

Specifically, to achieve an optimum tradeoff between acquisition costs, reliability, and LCC the program management team first determined the optimum range for design MTBF. This was done by comparing estimated acquisition costs versus O&S costs over a wide range of

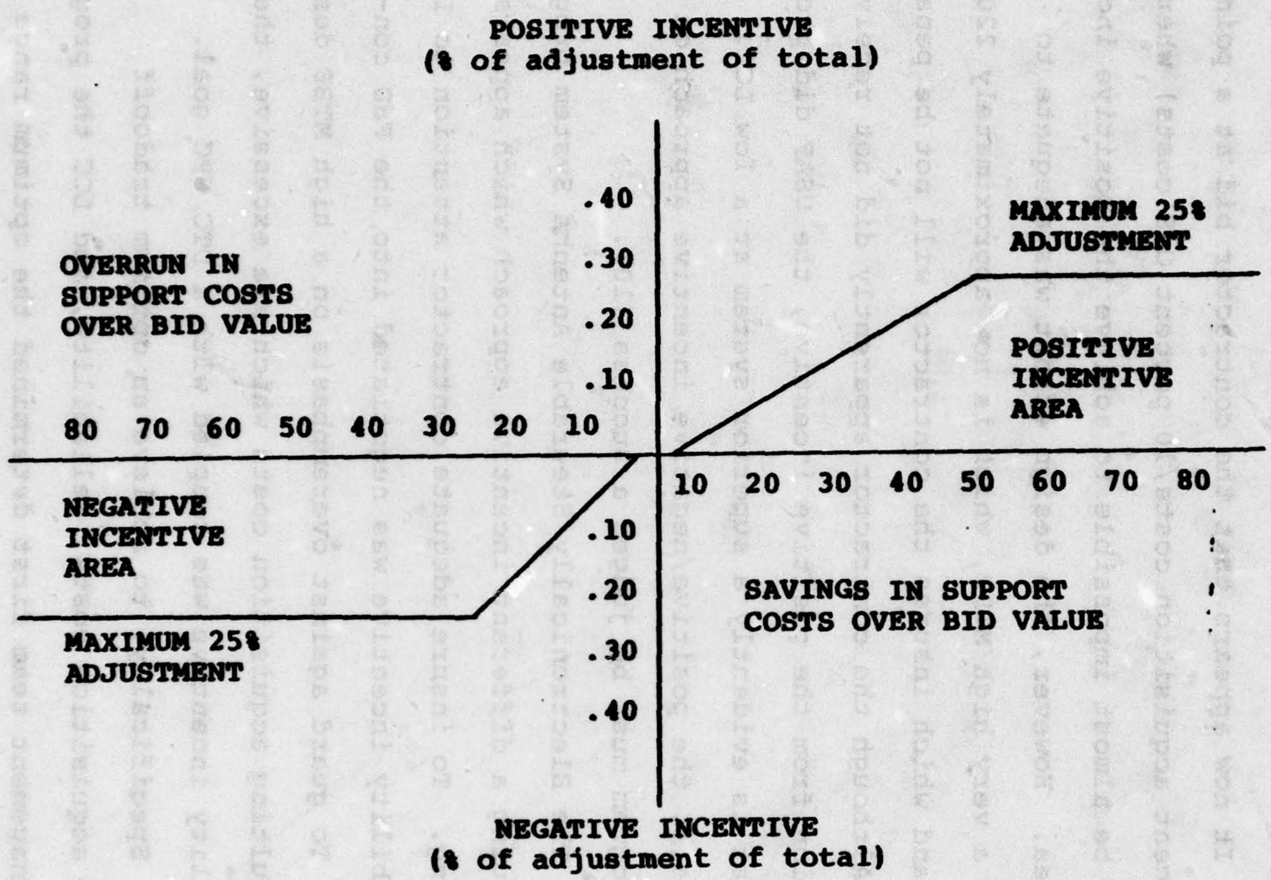

Fig. 3. AN/ARC-164 Incentive Provision (5:31)

MTBFs. This comparison, shown in generalized form in Figure 4, produced a total cost "flat spot" between the MTBF points shown as R_1 and R_2. R_1 and R_2 were then incorporated into the contract as an MTBF range which the contractor must achieve and demonstrate in a USAF monitored laboratory test. The MTBF achieved is incentivized by relating the number of failures experienced during the test to the amount of fee earned by the contractor. There is no negative incentive, as such, in the contract; however, the contractor receives no fee unless <u>both</u> the MTBF and DTC goals are reached (7).

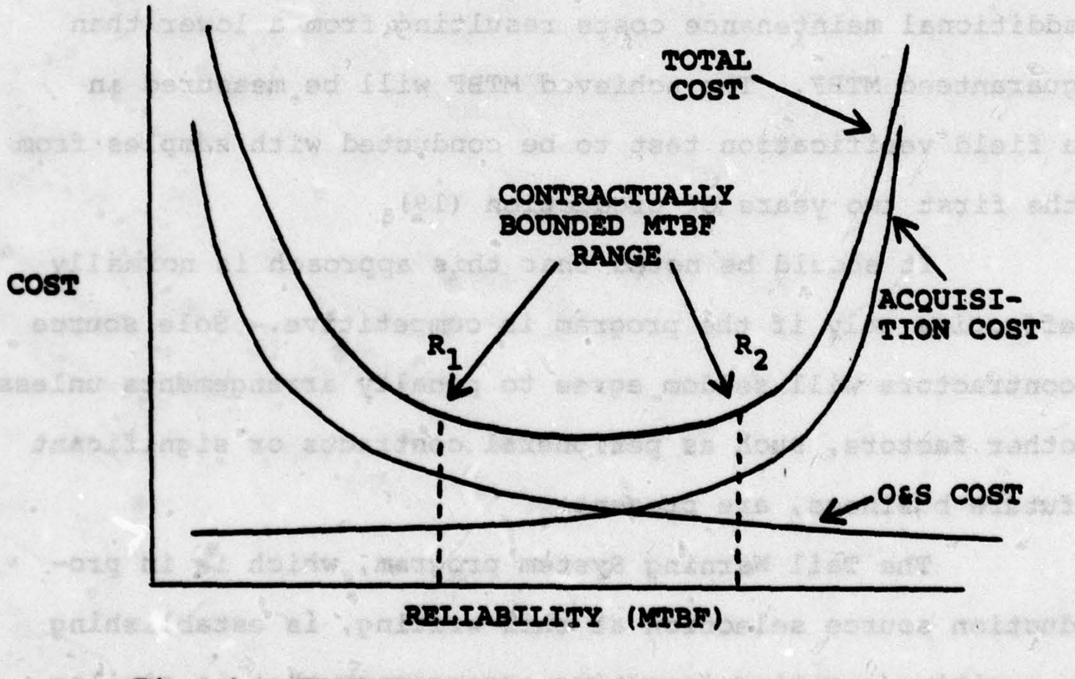

Fig. 4. ESAS Program: Relationship Between Cost and Reliability (7)

A highly promising negative incentive is being used on the AN/ARC-186 VHF radio program. The USAF specified a minimum acceptable MTBF in the production RFP with no specified upper limit. Contractors were allowed to propose any MTBF above the minimum, but the bid MTBF was required to be a guaranteed MTBF at equipment maturity. For source selection, the guaranteed MTBFs and the proposed acquisition costs for each bidder were input to the USAF model to derive the lowest LCC. To insure contractor compliance with the guaranteed MTBF, the contract contains a penalty clause which states that the contractor will supply the USAF with settlement spares and reimburse the USAF for the additional maintenance costs resulting from a lower than guaranteed MTBF. The achieved MTBF will be measured in a field verification test to be conducted with samples from the first two years of production (19).

It should be noted that this approach is normally effective only if the program is competitive. Sole source contractors will seldom agree to penalty arrangements unless other factors, such as peripheral contracts or significant future business, are present.

The Tail Warning System program, which is in production source selection at this writing, is establishing a positive/negative incentive arrangement that is similar in some respects to the ESAS discussed previously. The production contract award will be based on lowest LCC, but

LCC will not be incentivized as such because of verification testing problems in the SAC operational environment. Instead, both reliability, based on laboratory demonstration of MTBF, and DTC goals are incentivized in such a way that the contractor should be motivated to produce the equipment at minimum LCC. Specifically, the DTC goal, originally established during FSD in 1974, drives the base profit rate to be realized in the production contract. The base profit rate will be adjusted 1.4 percent for each \$10,000 increment the contractor produces above or below the DTC UPC goal with a maximum adjustment of ± 4.2 percent and a maximum possible profit of 15 percent. Without the type incentive arrangement, the maximum profit usually negotiated on this type of contract would be in the area of 10 to 12 percent.

To protect against contractor overemphasis on reaching the DTC goal at the expense of reliability, final profit will also be adjusted in accordance with the arrangement shown in Figure 5.

The contractor will gain an additional \$100,000 for each demonstrated ten-hour increment over the MTBF target of 200 hours to a maximum of 250 hours. On the penalty side, the contractor will loose \$500,000 for each ten hours below the minimum acceptable MTBF of 150 hours. Achieved MTBF will be verified by a laboratory test of

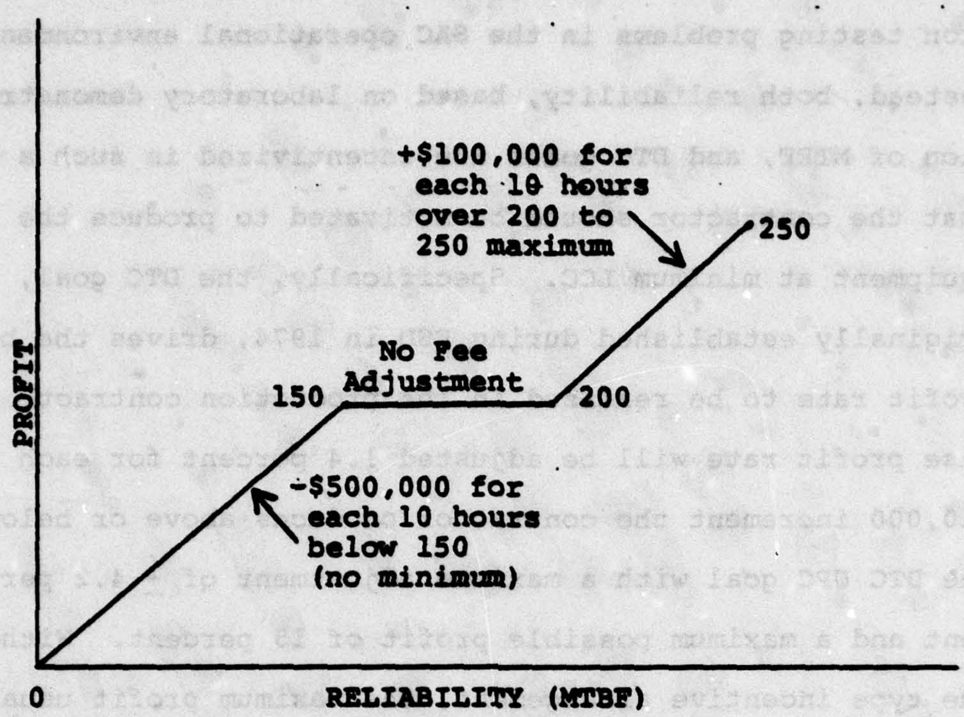

Fig. 5. TWS MTBF Incentive Provision (13)

two units randomly selected from the first production run of 40 plus a reliability acceptance test on each production unit.

This combination of incentives provides significant motivation to the contractor to reduce the UPC while increasing the system MTBF. However, if technical or production problems are encountered, the contractor has the overriding incentive to reach the MTBF target because of the extremely high penalty cost (13). Again, it should be noted that a competitive situation is required to enable

the USAF to negotiate penalty clauses of this type and magnitude.

Reliability Improvement Warranties

Reliability improvement warranties are not normally thought of as an approach to minimizing the LCC of a program. Under some circumstances, however, RIWs can provide significant motivation to contractors to improve equipment design and provide economical support which, in turn, reduces USAF ownership costs. Program managers should strongly consider the advantages and disadvantages of using a RIW approach before making final logistic support decisions.

While organic maintenance offers significant advantages, such as in-house maintenance capability, protection against strikes, increased control of assets and ability to accelerate operations under emergency conditions, the RIW approach also provides substantial advantages:

1. Strong contractor incentive to improve field reliability.
2. Possible reductions in USAF maintenance and support personnel.
3. Deferred support equipment decisions.
4. Less data (technical orders, parts breakdowns, etc.).
5. Fixed maintenance costs for the duration of warranty.
6. Greater protection to the USAF if equipment has low reliability (21).

Two programs that are currently using RIWs were examined. The OMEGA Navigation System, which was a competitive program through FSD with a production contract award based on lowest LCC, now has almost two years of field experience. The OMEGA production contract requires the contractor to fulfill the following obligations:

1. Maintain and update maintenance records.
2. Reach specified increasing MTBF goals during the warranty period at semiannual assessment reviews.
3. Accomplish no-cost-to-the-USAF engineering changes to reach the required MTBF.
4. Perform all required maintenance within a specified turnaround time.
5. Provide and manage all spare parts.
6. Provide consignment spares if MTBF commitment is not reached (27).

Experience to date indicates the contractor is meeting the required obligations, although the USAF has had some problems in fulfilling its contractual guarantees. Specifically, the USAF provided estimates on the number of equipment installations and flying hours to the contractor which formed the basis for the contractor's MTBF commitments and maintenance workload projections. Because of slippage in aircraft modifications at the cognizant ALC, and subsequent reductions in flying hours below the USAF projections, various contractual modifications have been required to allow the contractor more time to reach his

MTBF goal. Impact of the slippage has not been very significant other than increasing administrative workload and delaying deployment of needed equipment (27).

The other RIW program examined was the C-141 Attitude/Heading Reference System. This C-141 fleet modification is the only current RIW program with USAF intermediate level maintenance and contractor depot level maintenance. The contract provides for base level fault isolation and card replacement. If the equipment cannot be repaired at base level, the line replaceable unit (LRU) is shipped to the contractor's plant where the failure fault is jointly determined by DCAS and contractor inspectors within contractual guidelines (24).

Both the AHRS and OMEGA programs are currently experiencing fewer flying hours than were projected in their contracts, and upon which the contractors based their warranty cost estimates. Both contracts provide for a downward adjustment in warranty cost in this situation. If flying hours are higher than projected, both contracts provide for warranty costs to be adjusted upward.

A unique feature about both the OMEGA and AHRS programs is that very few Class I ECPs have been submitted since equipment deployment. None have been submitted on the AHRS and approximately three have been submitted on the OMEGA. Apparently, both contractors did intensive design work before and during initial production to increase reliability so that no ECP costs would be incurred

during the warranty phase. Part of the rationale for use of a RIW is that low MTBF equipment can be "grown" to a high MTBF during the RIW phase by engineering changes, but it appears that both contractors have avoided this expense by concentrating their design efforts early in the programs. While this is not the way the USAF originally thought the RIW concept would work, both program managers believe the USAF has benefitted in the long run by procuring more reliable equipment.

Generally, it appears that the RIW approach has advantages under some circumstances. If equipment is advanced state-of-the-art with a high potential for improvement, then use of a RIW should be thoroughly evaluated. On the other hand, if the equipment is subject to frequent changes as in ECM systems (39), or if the equipment is already highly developed with little growth potential, then a RIW is probably not economical (24).

LCC Verification Testing

Laboratory Versus Field Testing

When the major basis for production contract award is the LCC proposed by the bidders, the target LCC should be included in the contract as a firm commitment. When the LCC proposal is contractually incorporated, some procedure must be provided for actual measurement of the achieved LCC. This measurement can be accomplished by

either a laboratory test or by a field test under actual operating conditions.

Choice between a laboratory test or a field test is contingent upon many program factors. It is generally agreed by most program management and engineering personnel that field testing is more realistic and preferable to testing accomplished in a laboratory. The major reason is that it is difficult and expensive to duplicate the variety of conditions encountered in the field in a laboratory environment. Also, under some circumstances, contractors are able to "gold plate" or "fine tune" laboratory test articles to produce unrealistically favorable results. This problem of realistic reliability testing in a laboratory environment is one of the more significant problems facing LCC program managers in current programs (7).

Program managers who have decided to use laboratory testing instead of field verification have usually cited the following reasons:

1. Field testing is normally very time-consuming. Several years of operations are usually required to determine actual equipment reliability and maintenance problems with any degree of confidence (10).

2. Field testing is expensive to administer, especially in manpower terms (13).

3. Failure definition--determining what constitutes a failure and who caused it--can be extremely difficult to establish (13).

4. The USAF Maintenance Data Collection System (MDCS) is generally considered to be inadequate for test data reporting and contractual enforcement purposes. Therefore, the program manager must structure a separate reporting system (25).

5. Education, and re-education, of base level maintenance personnel about the requirements of the test program can become a burden (10).

6. Monitoring a test program and verifying failure data can be a significant difficulty in operational environments involving high security or frequent deployments (7).

In any event, the program manager must decide if the additional effort and expense involved in a field test are worth the increased data accuracy and higher confidence which is obtained. If a laboratory test is used, care must be taken to duplicate as closely as possible the conditions to be encountered in the field. Above all else in an LCC procurement, the contractor must be motivated to achieve the claims made in his proposal. If the contractor is not motivated, or if the USAF is unable to verify and enforce contractor compliance, then the objective of LCC procurement is lost.

Program Experience

Actual LCC verification test (LCCVT) experience at the subsystem level is extremely limited. In fact, the AN/ARC-164 radio is the only program examined which has actually conducted an extensive base level test of the contractor's reliability and maintainability claims. It now appears that the AN/ARC-164 LCCVT has been generally very successful, and is now providing important lessons learned and guidelines for other current and future programs. Some of the AN/ARC-164 experience is discussed below, along with pertinent information from other programs.

Structuring the LCCVT

The AN/ARC-164 program attempted to approximate in its test aircraft and locations the actual mix of USAF aircraft and environments. These include:

AIRCRAFT	COMMAND	LOCATION
T-37, T-38	Air Training Command (ATC)	Randolph AFB, TX
C-130	Military Airlift Command (MAC)	Little Rock AFB, AR
F-100	Air National Guard (ANG)	Barnes Municipal Airport, MA

The criteria used in selecting these aircraft and locations were: (a) that the aircraft have relatively high operating hours per month; (b) that the test sites be within the CONUS; and (c) that the aircraft be representative of the types of aircraft to receive the radio. The

test sites finally selected were considered representative of the varying climatic conditions of the fleet (1:12).

Maintenance Personnel

The AN/ARC-164 is being installed, maintained, and removed by USAF personnel. The original cadre was selected by the USAF, and trained and certified by the contractor. The USAF has attempted to maintain personnel stability to enhance continuity of effort, although this approach has been criticized as not being representative of real world USAF maintenance.

Each test base has a test director within its maintenance organization who is responsible for collecting all data and reporting to the program test director at Wright-Patterson AFB. Problems have been encountered because of frequent test director changes at Little Rock AFB due primarily to the MAC mission and the use of active duty personnel in this job. There has been better stability and continuity at the ATC and ANG bases because of their increased use of civil service and National Guard personnel in maintenance and test director duties (10).

Maintenance Data Reporting

Some authorities believe the USAF Maintenance Data Collection System is usable for failure reporting in support of an LCCVT if the conditions that follow are met:

1. The failure definition in the contract must be clear and understandable.

2. The Air Force Technical Order Forms 349 and 350 which accompany failed equipment to the depot must be correct.

3. Maintenance personnel at base level must be well trained on the importance of the test program and accuracy of documentation (26).

However, the AN/ARC-164 program management and test team did not feel the MDCS was adequate because of the following contractual and technical considerations:

1. The strong possibility of a substantial price adjustment resulting from test unit failures required extremely accurate reporting (1:24).

2. Under the MDCS, normal maintenance actions can be classed as failures and the same fault can be reported more than once under some circumstances (10).

3. In general, maintenance data reporting has a high error rate because of misrecording of items such as dates and codes, deletion of important items, and incomplete failure descriptions (26).

4. Base maintenance work unit codes and depot maintenance stock numbers are not compatible. Some system of conversion and accounting between the two systems would have had to have been devised (26).

Because of the above problem areas, the AN/ARC-164 program personnel developed a completely separate report used only for the LCCVT. The report is prepared monthly by the base level test directors and is used by program management and test personnel to track and analyze failures, monitor accumulated flying hours, and monitor the demonstrated MTBF by type of aircraft and location (10).

Failure Definition

In any program where large amounts of money depend on whether equipment operates or fails to operate, the definition of exactly what constitutes a failure is critical. This is particularly true in a LCCVT where significant contractual adjustments are contingent upon demonstrated equipment MTBF.

Although great care was taken to clearly define AN/ARC-164 failures and allow the contractor to witness all installations, maintenance, and removals, failure definition is still controversial. The contractor, for instance, believes that failures should be verified at depot level, while the USAF believes that base level is adequate. This was not clearly specified in the contract. Other instances have arisen where it was very difficult to tell whether a failure resulted from an equipment problem or from improper operation and handling by the USAF.

The extremely reliable operation of the radio has prevented this from becoming a significant problem. The Test Director, however, believes this could have become a major area of disagreement if the equipment had been less reliable and had driven O&S costs into the contractual penalty area (10).

Failure definition is a key element to a LCCVT. Failure definitions should be carefully developed and thoroughly reviewed by program management, engineering, procurement, and legal personnel prior to incorporation into the contract. Further, exhaustive discussions should be conducted with contractors before contract signature to insure the definitions and procedures are completely and clearly understood (30:35).

LCCVT Effectiveness

The AN/ARC-164 Test Director believes the verification test and special reporting system have been generally effective, providing the USAF with much better O&S cost visibility than would have been available through the MDCS or from a laboratory test. Although program funds were required to develop the original computer program for updating and calculating MTBF experience, that program is now available for other government users. While some problems have been encountered at base level due to personnel turnover, the bases have been extremely helpful

and cooperative to all program management and test personnel. Finally, it is estimated that the special monitoring and reporting system requires approximately .2 man years at ASD and .2 man years at each of the test bases. This appears to be a reasonable investment considering the number of systems and contractual dollars involved (10).

Other Programs

While the AN/ARC-164 is the only subsystem level program examined by the researchers which has significant operational verification test experience, several other programs deserve brief mention.

The AN/ARC-186 VHF Radio program, which has recently completed production contract award, has taken advantage of much of the experience gained and lessons learned on the AN/ARC-164 program and has attempted to make refinements and improvements wherever possible. The general program and verification testing structure are similar to the AN/ARC-164. It is too early to examine this program in depth, but it offers significant promise for future research (19).

The F-4 IMU program, discussed previously, employed an unusually rigorous acceptance test instead of a LCCVT, primarily because of the expense and time involved with field verification. This approach is not applicable on

all types of equipment, but could offer promise in some cases (31).

Finally, the ACES II program, mentioned earlier, is using a field random sampling technique to verify reliability instead of a LCCVT. In this sampling and surveillance program, seats are randomly selected in the field and returned to the factory where they are subjected to inspection and explosive verification testing. This test program provides the program office with a good picture of equipment reliability and LCC. Again, while only applicable to certain types of equipment, this technique might prove valuable in other situations (15).

Program Management Responsibility Transfer (PMRT)

Normally the program manager's final act on a program is the transfer of responsibility from AFSC to AFLC. In most cases AFLC will not accept program responsibility until the production contract is completed and closed out. In programs with lengthy LCCVTs and/or RIWs, AFLC refusal to accept responsibility can require the ASD program manager to maintain contractor surveillance and administrative responsibility for much longer periods than are considered desirable (24). While this is a parochial concern, it presents a real problem for ASD managers, and should be taken into consideration when structuring test programs and RIWs.

CHAPTER V

LESSONS LEARNED AND CONCLUSION

Life cycle costing has been discussed and emphasized within the DOD since the mid- and late- 1960s, yet it has only been within the past three or four years that LCC has been seriously applied in the acquisition of systems and subsystems. One of the major reasons for the lengthy delay is that a great deal of time and effort is required to change the basic orientation and management philosophy of a large organization.

Since the beginning of defense contracting, emphasis has been on procurement of equipment at the lowest acquisition cost. LCC procurement, on the other hand, can easily require that more funds be expended in the acquisition of equipment in order to save money in future operation and support of the system.

Another significant factor is that LCC must be used as a management philosophy throughout the entire weapon system management life cycle and not just as a technique that is applied briefly during the source selection phase of a program and then forgotten. To achieve significant reductions in O&S costs of systems and subsystems LCC must be understood and emphasized by all members of the program

management team, not only by the program manager. The program manager cannot accomplish the entire spectrum of LCC-related tasks by himself; he needs the assistance and support of procurement, engineering, cost analysis, logistics planning, and maintenance personnel. Each of these individuals must continually emphasize LCC in all of their dealings with contractors and they must use LCC as a major criterion in all program-related decisions.

Lessons Learned

All of the programs examined in this study were still in the acquisition phase; some were in FSD, while others were in source selection or in production and deployment. While final lessons learned on most of the programs will not be determined for at least another several years, the researchers believe the following items constitute major lessons learned to date and significant areas of concern for future program managers.

Early Emphasis

Maximum LCC effectiveness is obtained when LCC design and cost tradeoffs are made early in the conceptual and advanced development phases of a program. LCC can and should be rigorously applied in later program stages, but the later LCC tradeoffs are made, the more cost reduction opportunities are lost.

Contractor Involvement

At least until LCC techniques are better refined, contractors should be notified as early as possible of the USAF's intent to use LCC as a basis for contract award. Contractors should also be allowed to participate as much as is practicable in development, modification and refinement of LCC models, incentive provisions, and failure definition and test procedures.

High Cost Drivers

In many subsystems and items of equipment, a small number of components are the high cost, high failure rate, and high maintenance elements. Concentrating program design efforts and resources toward improvement or eliminating these few items can significantly improve long-range O&S cost performance.

Cost Estimating Relationships

CERs for most subsystems, especially avionics and electronic warfare equipment, are deficient. A great deal of work is required to improve cost analysis and cost estimating techniques for use in LCC modeling and in making program cost and design tradeoff decisions.

LCC Modeling

Use of computer models in source selection and other program phases is required to accurately assess contractor

LCC claims. LCC models can also be extremely valuable in other program applications such as determination of spares requirements, budget projections, and as continuing program control tools. There is a need for simplified models which can be used by managers of small programs who have limited resources and staff assistance.

Incentives

The effectiveness of positive incentives in LCC contracting is open to question. Generally, it appears that the presence of a strong negative incentive is the best motivator for good contractor LCC design and management. In some cases where thorough LCC design work has been done early in the program, and where there is competition for the the production contract, incentives are not required, and, in fact, probably only increase administrative complexity without improving LCC performance.

Reliability Improvement Warranties

RIWs can significantly lower O&S costs, but the application of RIWs seems limited to a fairly narrow range of programs. RIWs are not appropriate where equipment must be modified frequently in reaction to changing threats or where MTBF is already reasonably high.

Failure Definition

If a verification test, either field or laboratory, is used to confirm contractor LCC claims, the definition of exactly what constitutes a failure is a critical element of the contract and the test procedures. Also, the procedures for determining and certifying failures, and for contractor witnessing/participation in maintenance and fault correction are critical. These items should be thoroughly coordinated within the USAF, agreed to by the contractor, and clearly incorporated into the contract.

Verification Testing

If a LCCVT is to be conducted in an operational environment using organic maintenance, there are significant advantages to the use of ANG and ATC bases because of their better personnel stability and reduced turnover. Maintenance quality is not necessarily better at ANG and ATC bases, but the problem of frequent test program personnel re-education is lessened.

Recommendations for Further Research

The researchers believe the following LCC-related subjects offer significant potential for future research efforts:

1. Development of simplified LCC models which can be used by program managers with little or no staff support.

2. Improvement of current cost estimating techniques for avionics and related equipment.

3. Examination and possible standardization of contract provisions for LCC contracts.

Conclusion

While LCC has not been applied in the management of subsystem level acquisition programs until the past several years, a great deal of experience is now being accumulated on current efforts. Analysis of this experience and refinement of LCC principles and procedures should provide program managers significantly improved techniques for use in future programs, and should in turn result in better cost visibility and an overall reduction in USAF system ownership costs.

APPENDICES

APPENDIX A

PROGRAM SUMMARY

AD-A060 772 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OHIO SCHO--ETC F/G 15/5
APPLICATION OF LIFE CYCLE COSTING PRINCIPLES TO LESS THAN MAJOR--ETC(U)
SEP 78 J P CULP, S D NOVY
UNCLASSIFIED AFIT-LSSR-6-78B NL

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PROGRAM	CURRENT STATUS (DURING INTERVIEW)	COMPETITIVE SITUATION	LCC VERIFICATION METHOD	INCENTIVE ARRANGEMENT	REMARKS
Advanced Concept Ejection Seat	Production	Competitive until production contract award	No specific LCC verification--random field sampling	None	
AN/ARC-164 UHF Radio	Production	Competitive until production contract award	Field verification test based on MTBF and O&S costs	Positive/negative based on O&S costs	
AN/ARC-186 VHF Radio	Contract awarded for final R&D and production	Competitive until production contract award	Field verification based on MTBF	Negative only based on MTBF	
B-52/F-15 Tail Warning System	Production source selection	Competitive until production contract award	None--production reliability test	Positive/negative based on lab MTBF and DTC goal	
Carbon Brake Improvement for F-16	Component improvement R&D contracts with multiple sources	Will be competition for production contract	Laboratory and field test during R&D phase	None contemplated	

PROGRAM	CURRENT STATUS (DURING INTERVIEW)	COMPETITIVE SITUATION	LCC VERIFICATION METHOD	INCENTIVE ARRANGEMENT	REMARKS
C-141 Attitude/Heading Reference System	Production	Competitive until production contract award	None	Negative if MTBF guarantee not reached	5-year RIW
Electronically Steerable Antenna System	Full Scale Development	Sole source	Laboratory MTBF Test	Positive based on MTBF and DTC goal	
F-4 Inertial Measurement Unit	Production	Competitive until production contract award	None--production reliability test	None	
OMEGA Navigation System	Production	Competitive until production contract award	None	Negative if MTBF guarantee not reached	5-year RIW
Survival Avionics System	Full Scale Development	Sole source prime contract--competitive radio subcontract	None	None	

APPENDIX B

INTERVIEW GUIDE

Section 1

1. Did your program have any features or characteristics which made it particularly easy or difficult to apply LCC characteristics?

2. What were your most difficult LCC problems and how did you deal with them?

3. What do you feel are/were the most successful LCC aspects of your program?

4. Do you feel your program developed any significant and/or unique approaches to the application of LCC principles?

5. Do you feel there are effective ways to apply LCC principles to FSD and production programs, or is effective application limited to conceptual and advanced development program phases?

6. At what point should production contractors be consulted, or allowed to participate in, the formulation of an LCC plan?

7. Have you received any meaningful LCC assistance from AFSC laboratories?

Section 2

8. What types of LCC models have you used?

9. What were the strengths and/or weaknesses, if any, of the model(s)?

10. From what sources did you obtain cost/performance/ mission inputs for the model? Do you feel the data was adequate?

11. At what point in your program was the final support concept determined?

Section 3

12. Was there any attempt to perform a formal risk analysis from the contractor's viewpoint prior to release of the RFP or prior to contract negotiation?

13. How were your source selection criteria structured and weighted?

14. In your opinion, what is the best approach to the elimination or control of contractor "gaming" during proposal and source selection/negotiation phases?

15. Do you believe that LCC should be the primary basis for contract award?

Section 4

16. Do you believe there are effective ways to motivate contractors toward LCC reduction other than economic incentives and/or penalties?

17. Do you think it is possible, or desirable, to structure standard LCC contract clauses?

18. How do you feel about each of the following techniques as effective contracting approaches in LCC-based procurements:

    a. Contracts with incentives only.
    b. Contracts with penalties only.
    c. Contracts with both incentives and penalties.
    d. Reliability improvement warranties.
    e. LCC as a source selection evaluation factor only.

Section 5

19. What do you feel is a reasonable time period to hold contractors responsible for the O&S costs of their equipment?

20. Does the current maintenance data reporting system provide adequate feedback to demonstrate contractor compliance with contract LCC provisions? If not, how did you solve this problem?

21. What are your recommendations for structuring the following aspects of LCC field verification:

    a. Qualification testing.
    b. Verification testing.
    c. Maintenance feedback.
    d. Failure definition.

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